PENGEMBANGAN METODE *MULTI-INTERVAL DAY-AHEAD* OPTIMAL POWER FLOW MENGGUNAKAN TEACHING LEARNING BASED OPTIMIZATION UNTUK SISTEM TENAGA LISTRIK DENGAN PENETRASI PHOTOVOLTAIC

DISERTASI

Karya Ilmiah sebagai salah satu syarat untuk menyelesaikan jenjang strata tiga (S-3)
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Judul	Pengembangan Metode *Multi-Interval Day-Ahead Optimal Power Flow* Menggunakan *Teaching Learning Based Optimization* Untuk Sistem Tenaga Listrik Dengan Penetrasi *Photovoltaic*	Ricky Maulana
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Abstrak

Peningkatan penetrasi pembangkit energi terbarukan, khususnya photovoltaic (PV), menimbulkan tantangan baru pada operasi sistem tenaga listrik akibat karakteristik intermiten dan ketidakpastian daya keluarannya. Kondisi ini menyebabkan metode optimal power flow (OPF) konvensional menjadi kurang representatif untuk sistem tenaga modern berbasis smart grid. Penelitian ini bertujuan mengembangkan metode aliran daya optimal satu hari ke depan berbasis multi-interval dengan integrasi peramalan daya PV dan optimasi multi-objektif terhadap biaya pembangkitan serta rugi-rugi daya. Metode yang dikembangkan menggunakan model Seasonal Autoregressive Integrated Moving Average (SARIMA) untuk memprediksi daya keluaran PV selama 24 jam ke depan yang diintegrasikan ke dalam kerangka multi-interval OPF. Proses optimasi diselesaikan menggunakan algoritma Teaching Learning Based Optimization (TLBO) dan hybrid TLBO-Pareto untuk memperoleh solusi kompromi terbaik antara biaya operasi dan rugi-rugi daya sistem. Pengujian dilakukan pada sistem IEEE 30-bus yang dimodifikasi dan sistem kelistrikan riil Sumatra Barat dengan integrasi PV pada bus GI Solok. Hasil penelitian menunjukkan bahwa metode yang diusulkan mampu memenuhi batasan teknis sistem pada seluruh interval pengamatan. Pada pengujian IEEE 30-bus, pendekatan SARIMA-OPF menghasilkan biaya operasi rata-rata 777,82 \$/h, lebih rendah dibandingkan pendekatan single-interval probabilistik Barnacles Mating Optimizer (BMO) sebesar 827,95 \$/h. Integrasi peramalan PV dalam kerangka day-ahead multi-interval OPF mampu merepresentasikan kondisi operasi sistem tenaga listrik secara lebih realistis dan adaptif terhadap variasi pembangkitan energi terbarukan.

Kata kunci: *Optimal Power Flow, Day-Ahead OPF, Photovoltaic, SARIMA, Teaching Learning Based Optimization*

Title	*The Development of a Multi-Interval Day-Ahead Optimal Power Flow Method Using Teaching-Learning-Based Optimization for Electric Power Systems with Photovoltaic Penetration*	Ricky Maulana
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Abstract

The increasing penetration of renewable energy generation, particularly photovoltaic (PV), poses new challenges for power system operations due to the intermittent nature and uncertainty of its output. These conditions render conventional optimal power flow (OPF) methods less suitable for modern smart grid-based power systems. This research aims to develop a multi-interval day-ahead optimal power flow (OPF) method that integrates PV power forecasting and multi-objective optimization of generation costs and power losses. The developed method employs a Seasonal Autoregressive Integrated Moving Average (SARIMA) model to forecast PV power output for the next 24 hours, which is integrated into the multi-interval OPF framework. The optimization process is solved using the Teaching Learning Based Optimization (TLBO) algorithm and a hybrid TLBO-Pareto algorithm to obtain the best compromise solution between operational costs and system power losses. Testing was conducted on a modified IEEE 30-bus system and the real-world West Sumatra power system with PV integration at the GI Solok bus. The results show that the proposed method is capable of meeting the system's technical constraints across all observation intervals. In the IEEE 30-bus test, the SARIMA-OPF approach yielded an average operating cost of $777.82/h, which is lower than the $827.95/h achieved by the single-interval probabilistic Barnacles Mating Optimizer (BMO) approach. The integration of PV forecasting into the multi-interval day-ahead OPF framework can more realistically and adaptively represent the operating conditions of the power system in response to variations in renewable energy generation.

Keyword *: Optimal Power Flow, Day-Ahead OPF, Photovoltaic, SARIMA, Teaching Learning Based Optimization.*